AFTA-WFIRST
Astrophysics Focused Telescope Assets - Wide-Field Infrared Survey Telescope (WFIRST)

Kevin Grady

January 10, 2013

Agenda – 1st Day

9:00 Welcome	Nick White
9:05 Organization & Introductions	Gehrels / Spergel
9:15 Final Report - DE & Fundamental Cosmology	Weinberg
9:35 Final Report - Science Overview	Dressler
9:55 Final Report - Galactic Plane Survey	Kalarai
10:15 Final Report - Exoplanet Microlensing	Gaudi
10:35 NASA HQ Update	Hertz
11:20 Break	
11:35 Final Report - Exoplanet Coronagraphy	Kasdin
11:55 Project Update #1A	Grady, Content et al.
12:55 Lunch	
2:00 Discussion	
2:20 Final Report - High Latitude IR Survey	Postman
2:40 Final Report - Guest Observer Program	Greene
3:00 Final Report - Table 2.1	Moos
3:20 Final Report - Relation to Other Observatories	Rhodes
3:40 Break	
4:00 Cosmic Ray Dosage and Shielding in GEO	Kruk, Hirata
4:30 Ball Aerospace	Dennis Ebbets, Jim Oschmann
5:00 Discussion	
6:15 Adjourn	
6:45 Dinner (Long Beach)	

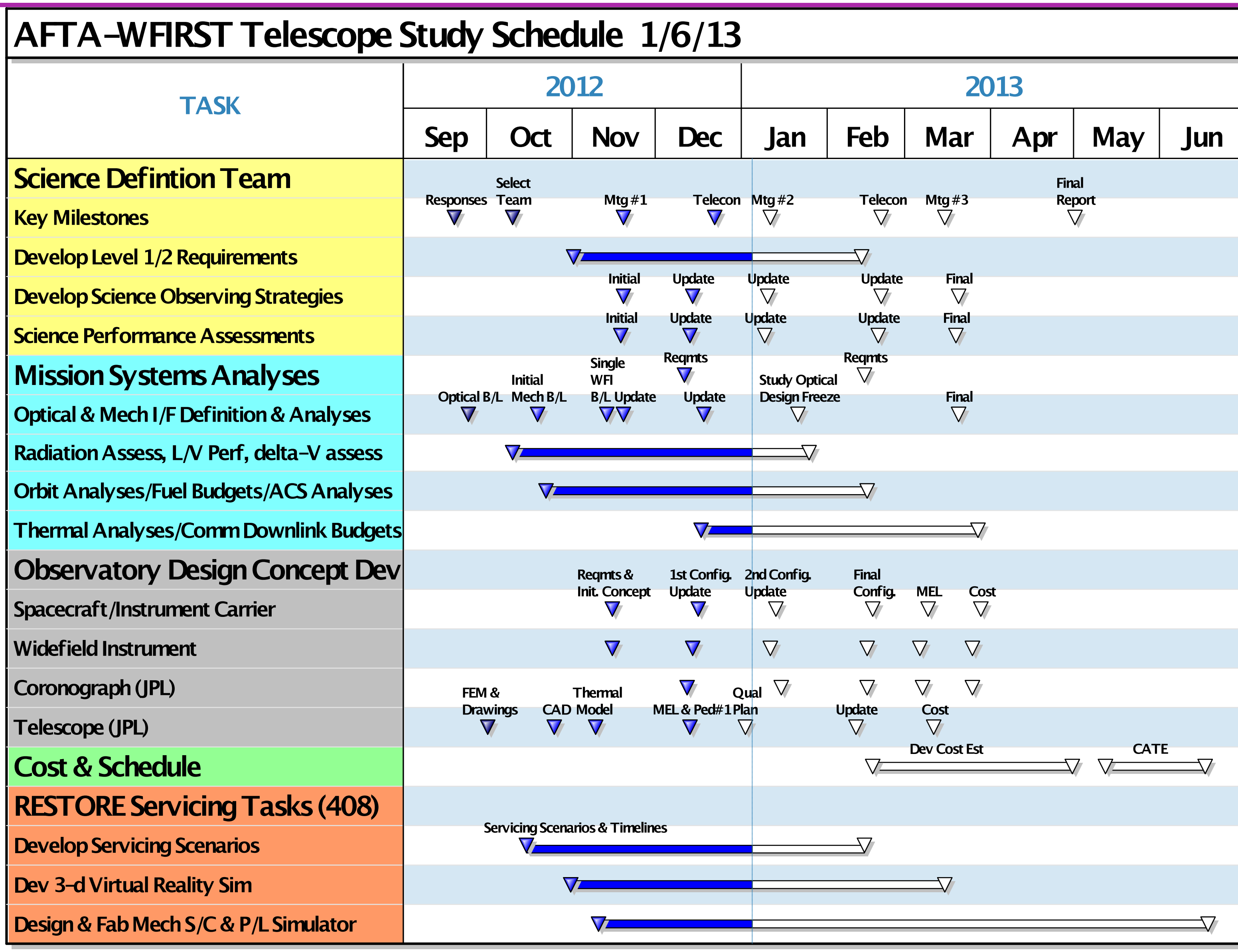
Agenda – 2nd Day

8:30 Welcome	George Helou
8:35 Organization	Spergel / Gehrels
8:45 Coronagraphy Update	Kasdin, Guyon, Shaklan
10:00 Break	
10:15 IFU Update	Perlmutter, Content
10:45 Project Update cont.	Grady, Content, et al.
12:00 Lunch	
12:30 Observing Plan	Hirata
1:30 Discussion	
2:30 Adjourn	

Accomplishment Highlights

- Completed trade of overall observatory mechanical configuration options. Continued weekly meetings with RESTORE to incorporate servicing capability into system design.
- Assessed the thermal performance of the AFTA telescope in a GEO orbit – goal was to select baseline temperature for this study. Many opportunities are available in future studies to improve performance.
- Radiation – Currently conducting an ongoing analysis of detector performance in the GEO radiation environment and any implications to instrument system design (i.e detector shielding, readout approach and impacts to instrument data rate, etc)
- Completed initial design cycle on Widefield instrument.
- Coronagraph – Established mechanical interface volume for the study and the Coronagraph Team performed multiple packaging iterations of potential coronagraph conceptual designs.
- Continuing to assess launch vehicle options (flight dynamics & KSC) for GEO orbit. Goal is the most economical launch service scenario.
- Began dialogue with GSFC’s Laser Communications Relay Demonstration Project. In the process of developing the complement of flight & ground hardware that would form the basis of the AFTA-WFIRST Laser Comm Option.
- Active Control Study – Began assessment of a cost-constrained option that would leverage off of the heritage mechanisms on the secondary mirror, to enable an active optic control capability for AFTA-WFIRST. By necessity, this assessment will have to have a longer term time horizon. Quantify verification advantages and potential new science enabled.

AFTA-WFIRST Study Schedule



Looking Ahead

- Costing effort just over the horizon.
- Need to finalize configuration in the next 5 weeks (mid-February).
- Develop Master Equipment Lists (MELs) for all hardware.
- Run parametric cost models and develop supporting grassroots estimates.
- Implementation phase schedule has been drafted.
- Develop Project’s Life Cycle Cost (LCC).
- Report completion: April 30, 2013.
- Initiate CATE independent cost and technical assessment.

Wide Field Instrument Update

D. Content and wide field instrument team

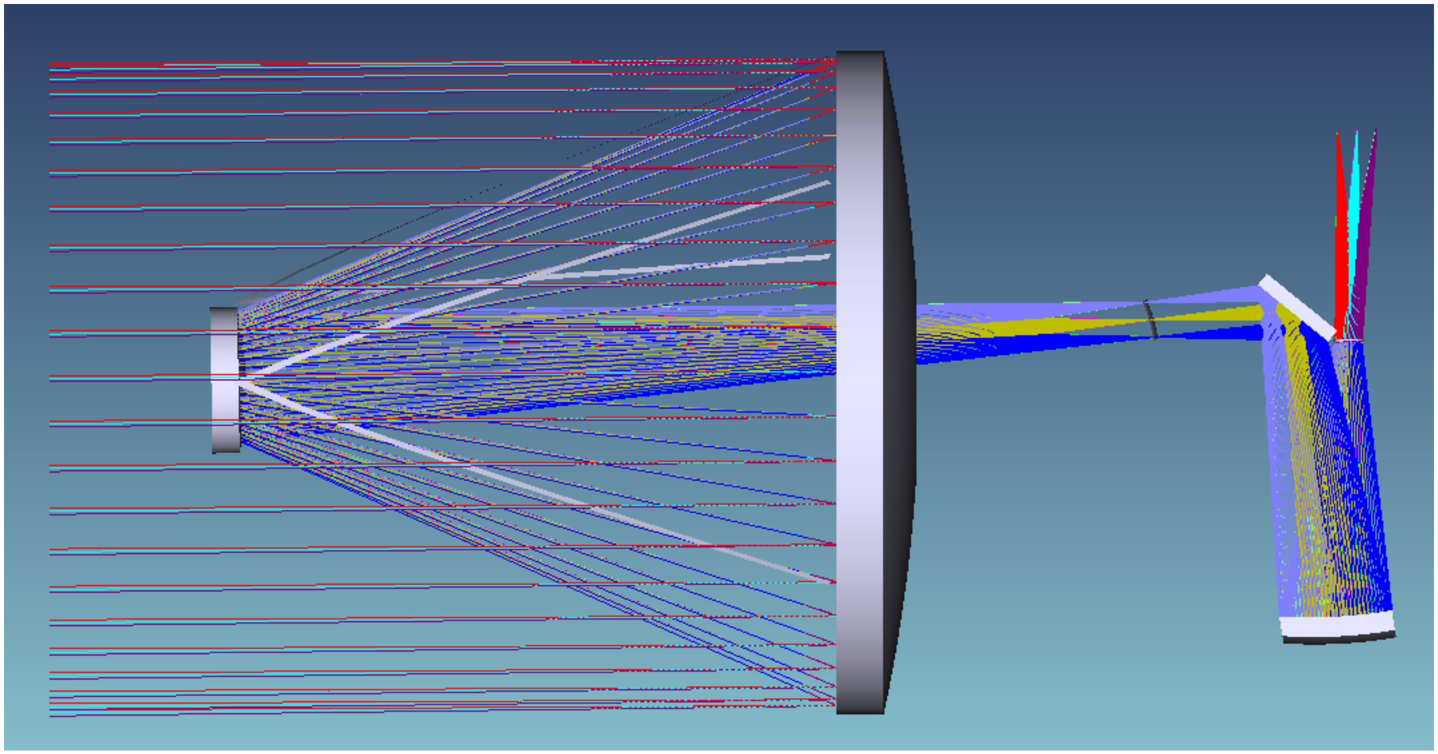
Wide Field instrument update

- Recently completed preliminary review of WF concept
  - 3 mirror camera
  - Combined all filters, SN prism, GRS grism in single wheel
  - Thermal modeling progressing
  - Volumetric accommodation for WF and coronagraph
  - SN prism and single 1.3-2.0um grism
- New instrument design underway
- Still 6x3 layout used
  - Closely packed but final value pending details of new sapphire radiation window in front of FPA

New WF design

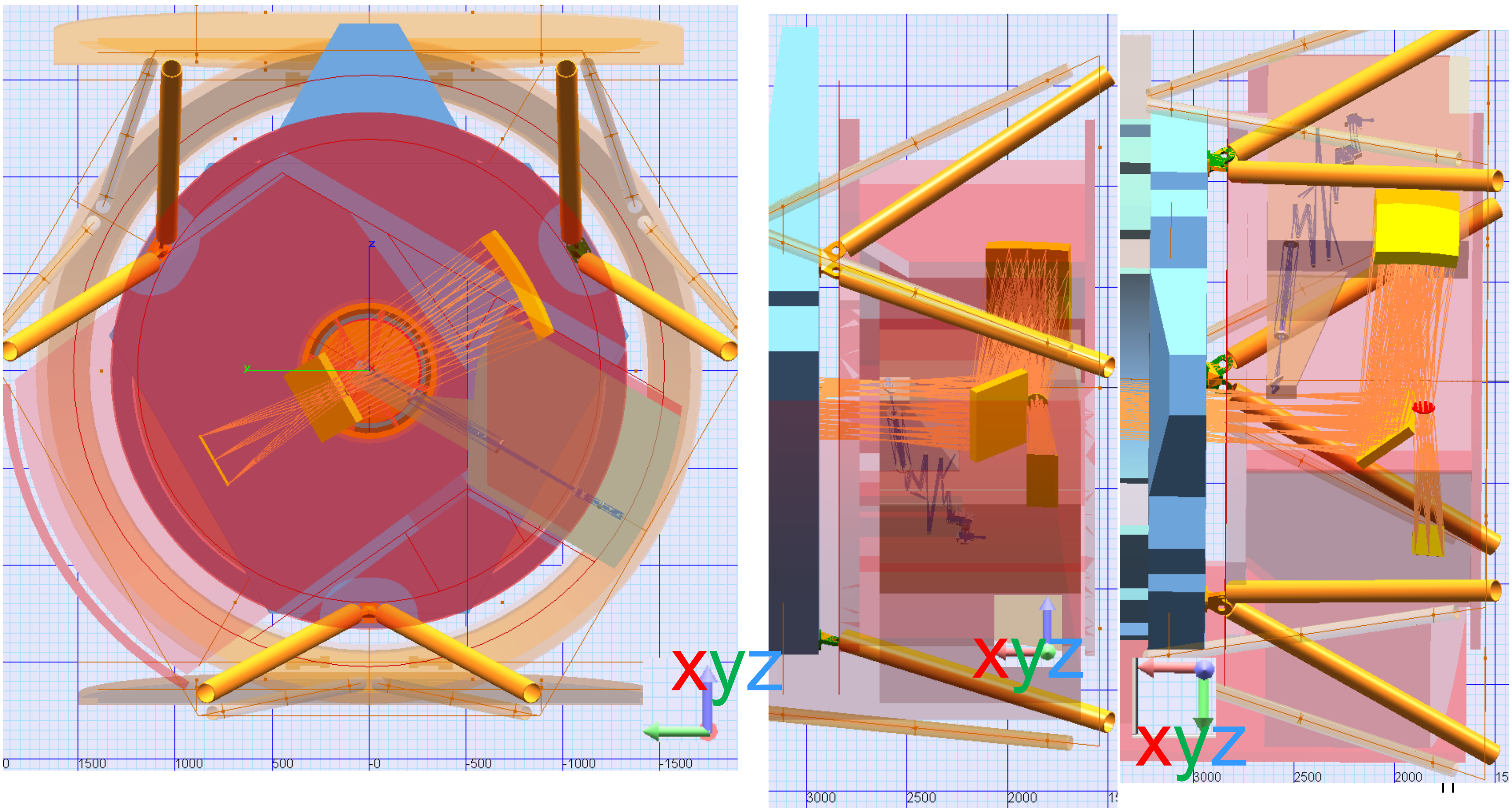
- Instrument volume substantially reduced, likely easier for servicing
- Sapphire window being added in front of FPA for radiation shielding in Geo orbit (not shown below)
- Coronagraph interface viable, need to work details
- Currently has lien on grism design
  - We think if the grism can be designed, we can guide off the zero order
  - Then if we add an IFU, the aFGS would not be needed

Preliminary Opto-Mechanical layout

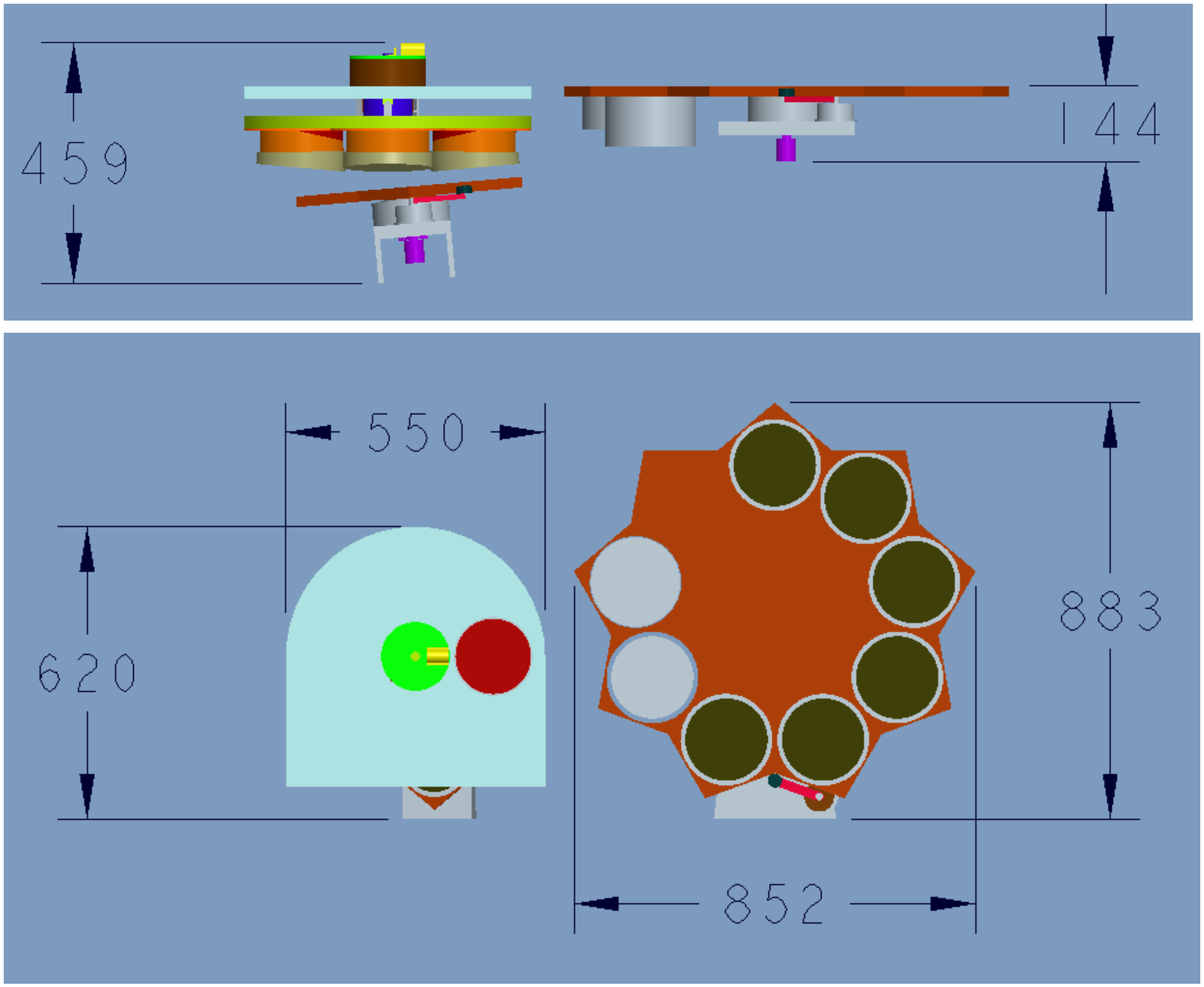


- Similar to SNAP, single folded TMA
- Packaging is ongoing, likely this is not the final form

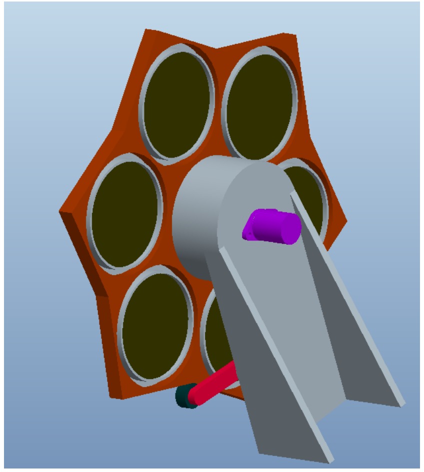
Preliminary layout – CAD view



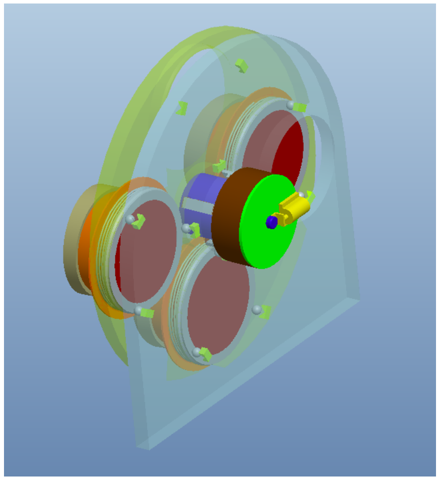
Element wheel Dimensions



Mass Comparison

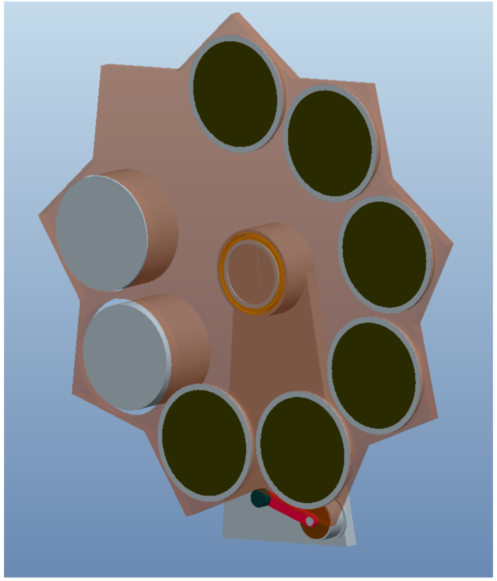


15.9 kg



65.4 kg

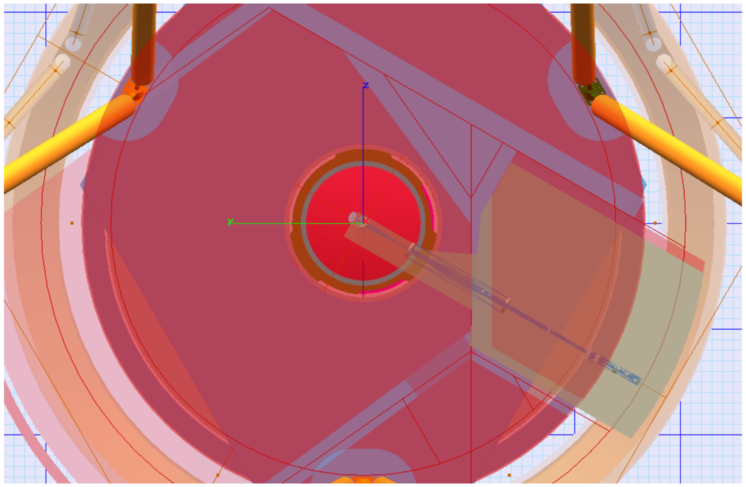
Total 81.3 kg



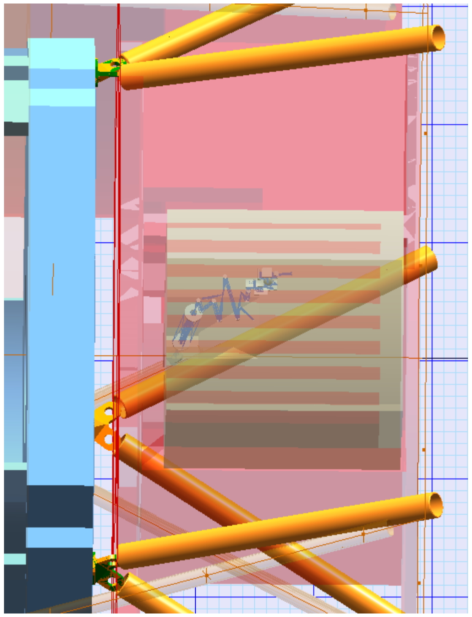
Total 59.6 kg

Coronagraph accommodation

- Requirement – two cold bays, use one for WF servicing (+y) and one for coronagraph (-y)
  - Remove either w/out perturbing other
    - "radially non interlocking volume" constraint
- Coronagraph picks off telescope beam in front of intermediate focus; WF pick off behind focus
  - Axial separation near axis
- Coronagraph pickoff and subsequent optics in a "snout" extending in to axis



View from aft – tan is Coronagraph volume



View from insertion/ removal direction

Study plan

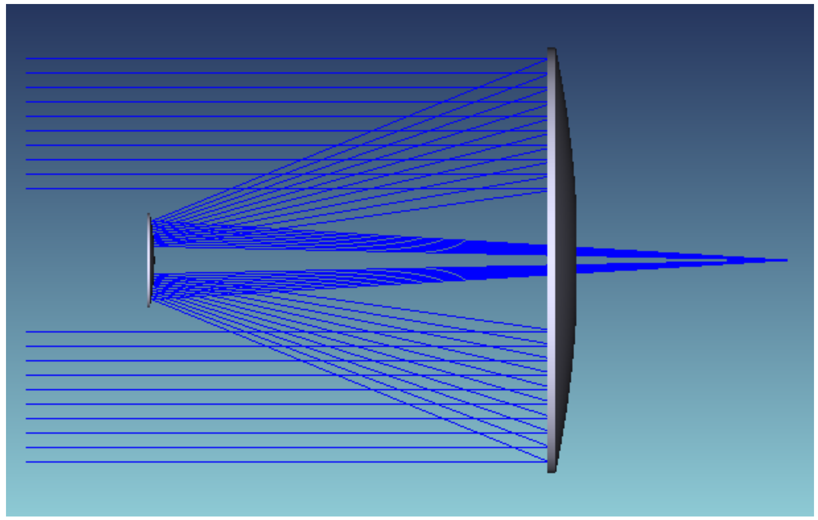
- Complete packaging
- Address grism lien
- Work thermal design
- Update performance
  - Optical imaging performance in imaging, SN spectroscopy, GRS grism modes
  - throughput
  - Mass rackup
  - Power rackup

Active optics on AFTA WFIRST

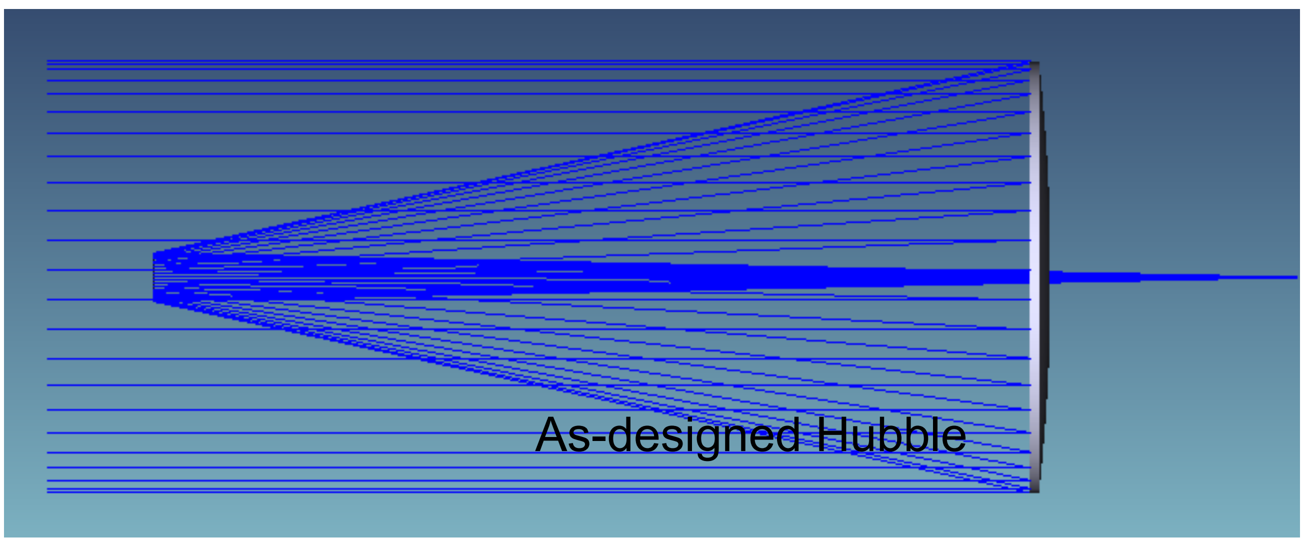
- Potential for improved imaging and stability
  - Closed loop T2-T1 rigid body position stabilization
  - Would provide a major distinction vs. HST
  - Consistent with all modern groundbased telescopes
  - May be needed for AFTA WFIRST in Geo orbit (needs study)
- Could be readily implemented in telescope & WF instrument
  - Additional engineering-grade pixels out of focus added to corners of WF instrument
    - Curvature or defocused phase retrieval approaches
  - Wavefront retrieval signal fed back at low frequency (0.01-.001 Hz) to counteract thermoelastic drift
  - May require qualification for more routine use of 6 T2 strut actuators
    - Same motor was qualified for fine focus control

Layout comparison, NRO vs. Hubble

NRO telescope



System length ~ 3.5 m
Primary ROC ~ -5.67 m
Primary, F/1.2
F/# ~ 7.6
EFL ~ 18.23 m
PSF FWHM ~ 11.7 um
(132 mas)
Primary mass ~ 1/5
that of Hubble.



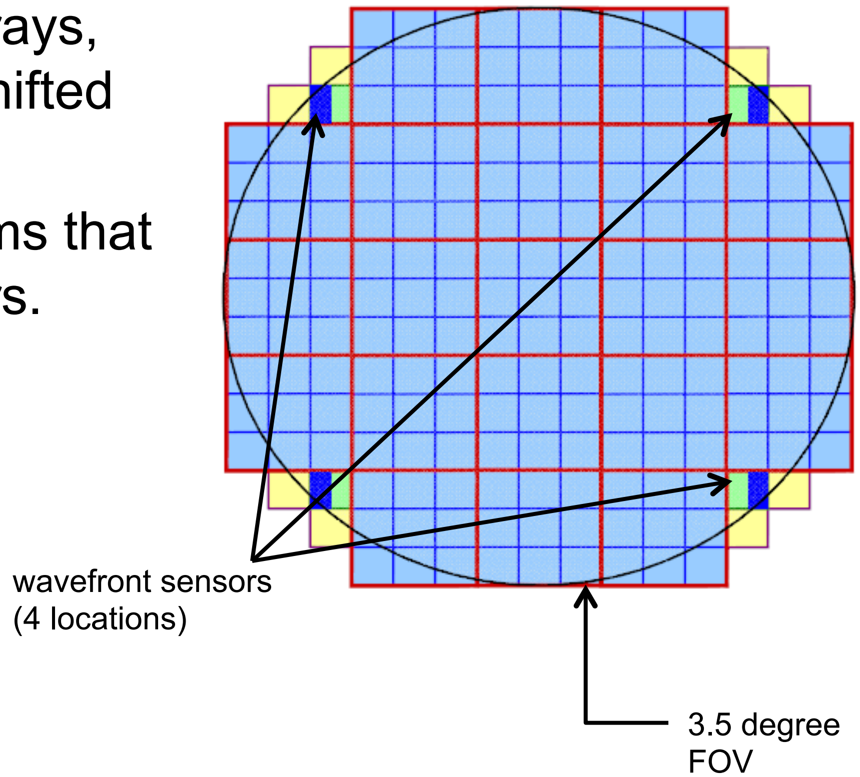
System length ~ 6.3 m
Primary ROC ~ -11.0 m
Primary, F/2.3
F/# ~ 23.7
EFL ~ 56.9 m
PSF FWHM ~ 36 um
(132 mas)

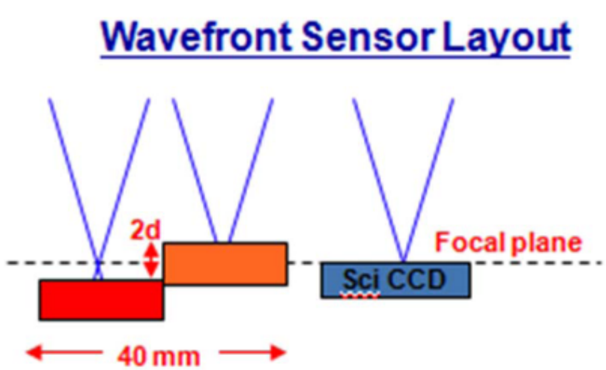
E. Elliott/StSci

LSST focal plane layout – example implementation

- LSST focal plane contains dedicated regions for WFSC.
- Each region contains two arrays, one shifted upstream, one shifted downstream.
- Drastically superior to systems that point away to calibration stars.
  - Aligns a wide field.
  - Continuous operation.

LSST image plane layout





References: LSST Wavefront and Alignment Sensing Design Summary, LTS-115, Chuck Claver, 23 August 2011.
Curvature wavefront sensing performance evaluation for active correction of the Large Synoptic Survey Telescope, A. Manual, D. Phillion, S. Olivier, K. Baker, B. Cannon. Optics Express , Vol 18, No 2, page 1528.

Short term plan

- Study feasibility
  - Signal to noise & computation requirements for various control types
    - Curvature sensor
    - Defocused wavefront retrieval
  - Simulate closed loop performance
    - Potential imaging improvement vs. passive baseline approach previously used
- Estimate cost
  - Additional sensors (can tolerate more noise, poorer cosmetic quality to improve yield and reduce cost/schedule)
  - Software development and testing

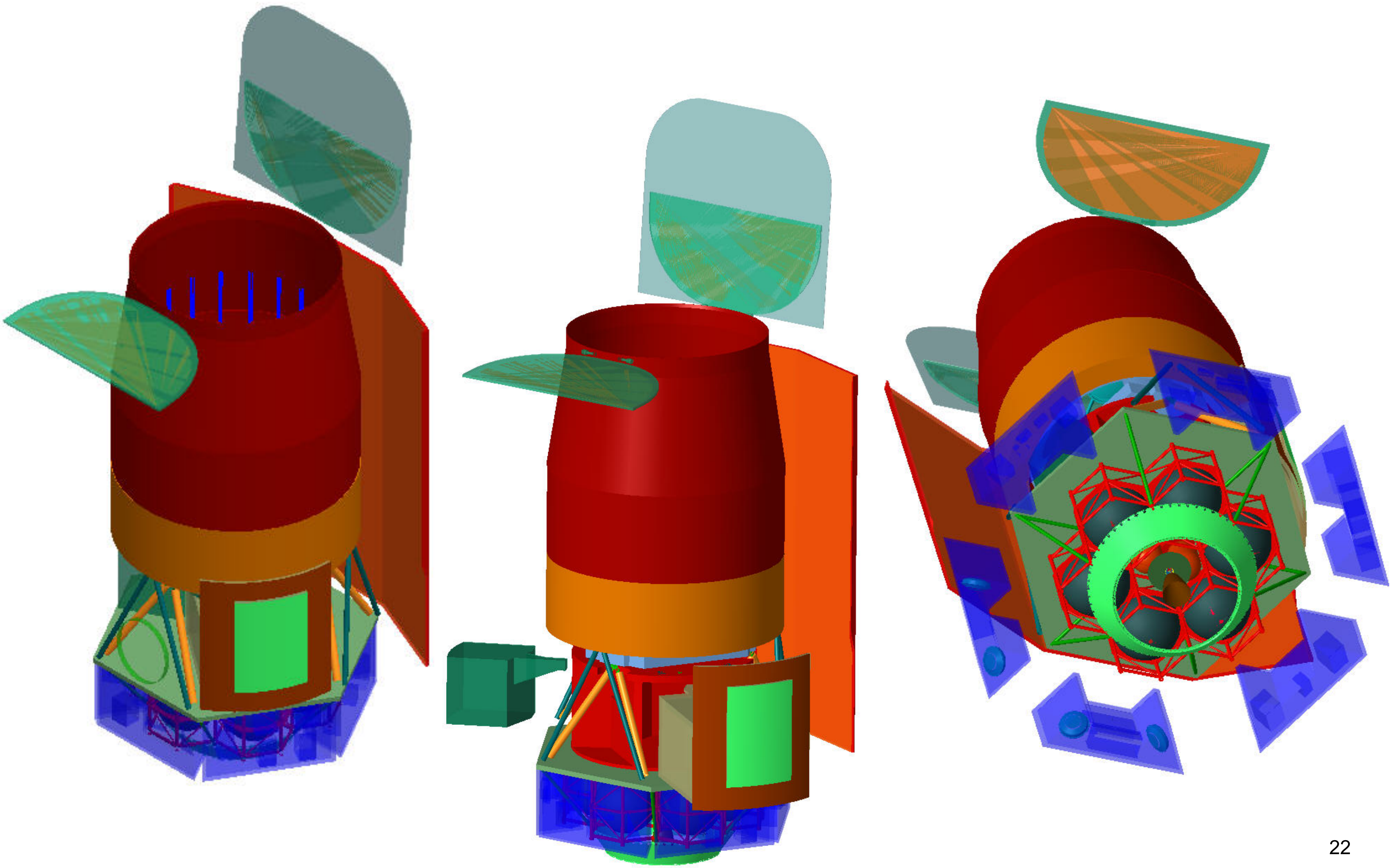
Observatory Update

Mark Melton, GSFC

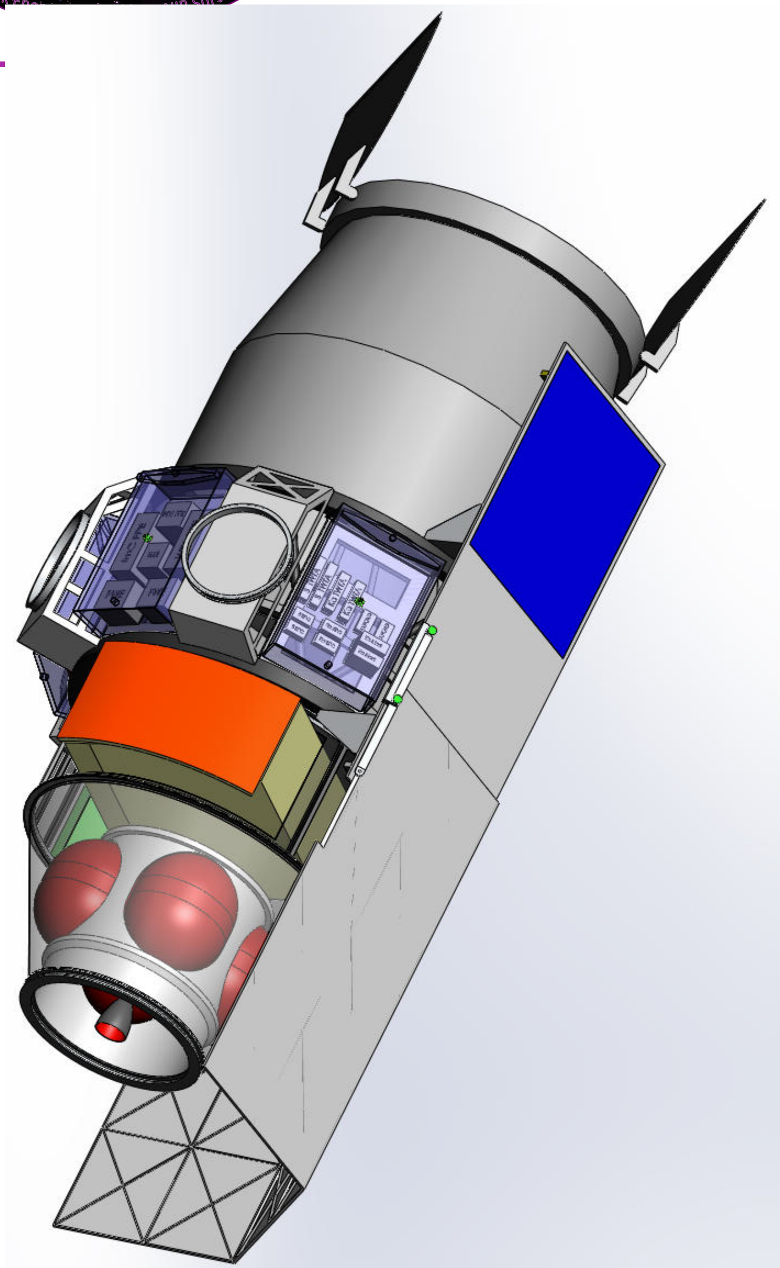
Observatory Configuration Trade

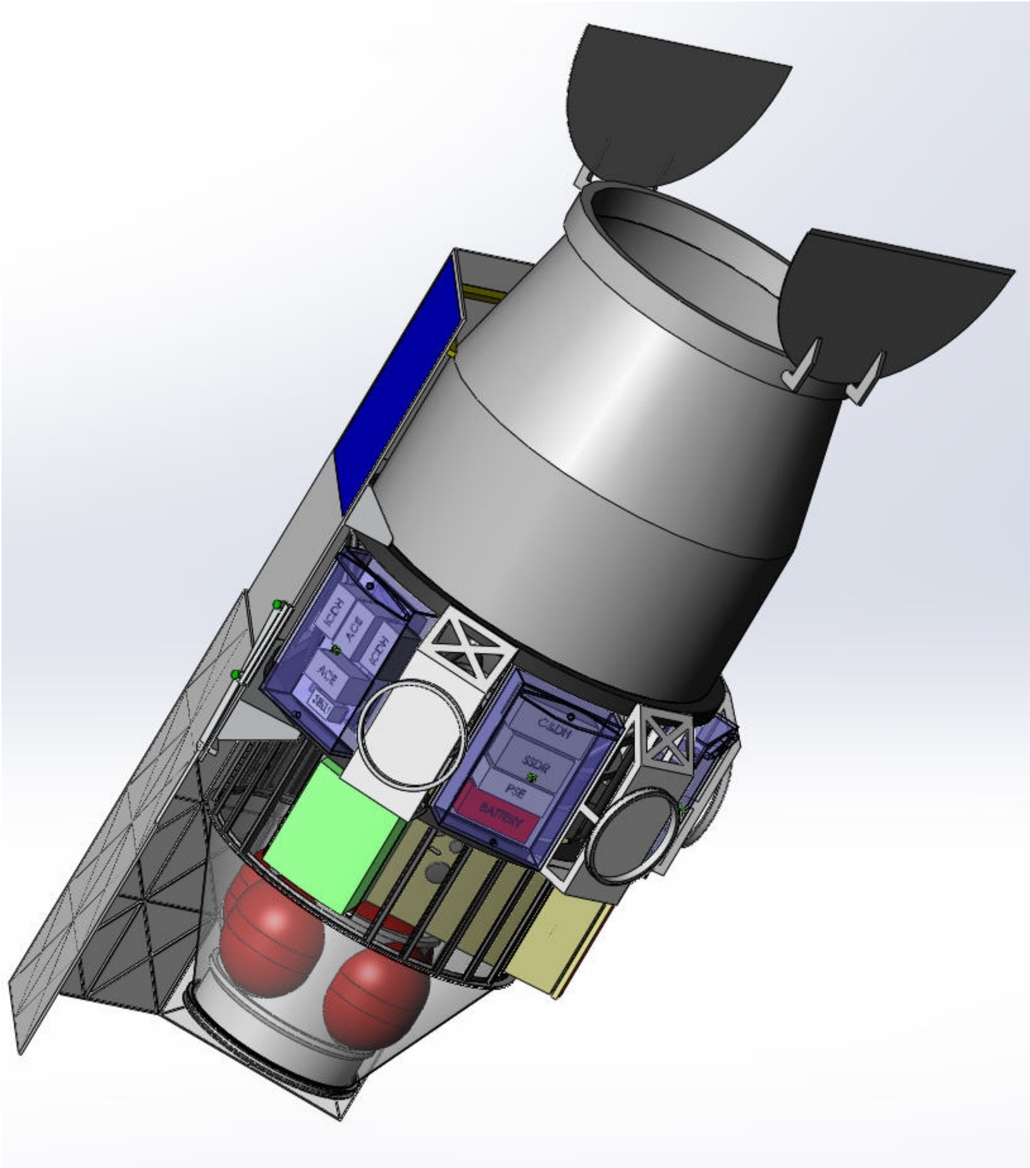
- Assessed two options for Observatory configuration
- Initially started as a trade between radially and axially serviced instruments
- Both concepts use the same instrument designs
- Decision was based on a number of factors including:
  - Mass (drives cost)
  - Serviceability (RESTORE team assessed servicing of these concepts)
  - Mapping efficiency
  - Momentum buildup
- Configuration 1 chosen as the baseline for this study

Configuration 1



Configuration 2





Comm System Update

- 3 Potential RF Comm System Configurations
  - Baseline the SDO design again for WFIRST. This is a 150 Mbps, TRL 9 design.
  - Scale up the SDO design (involves changing some component values in the modulator to increase the data filter bandwidth). This is scaleable to 400 Mbps. ~TRL 7
  - Baseline the new GSFC Ka modulator in development on the IRAD. This is capable of up to 1.2 Gbps. Modulator is TRL 5 and will reach TRL 6 after testing this summer.
- Initial discussions held with laser comm group (2 options)
  - Flight demo of laser comm (LLCD) is scheduled to launch in May with a data rate of 622 Mbps
  - Second demo (LCRD) is in Phase A with 2017 expected launch will have a data rate of 1.2 Gbps
- Radiation analysis is still ongoing (see Kruk presentation) and will drive the downlink requirements

Science Data Rate Possibilities

- Initial assessment used 20 detectors (18 wide field data and 2 aux FGS, large compared to coronagraph), 2x lossless compression, and a detector readout rate of 5.3 secs
- Case 1 – Use SUTR with a single output per integration time
  - Use microlensing obs (assume 47.7 sec integration, 9 samples) gives a max science data rate of 56 Mbps
- Case 2 – Use SUTR with a few samples to reduce the impact of the radiation environment
  - Assuming 4 samples, 21.2 sec integration, gives a science data rate of 127 Mbps
- Case 3 – Downlink each sample
  - Reading out every samples gives a science data rate of 506 Mbps

Summary

- Observatory configuration set for report
  – Will now focus on refining spacecraft design
- Radiation analysis ongoing
- High TRL comm system can support GEO ops if shielding reduces radiation environment sufficiently to allow the use of the SUTR algorithm